Research of Comprehensive Utilization of Coal Gangue

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Abstract. Oil and coal are abundant in China and it is a superiority for the development. Coal gangue come from the course of coal exploitation, and processing, which is one of the solid wastes of industry biggest in emission of our country. How to solve this environment pollution and effectively utilize the coal gangue is a main subject and difficult problem faced at present. In this paper, we performed a comprehensive analysis of the development about comprehensive utilization of coal gangue, and provided a basis for the research of coal gangue and environmental protection.

Introduction

China is the world's largest coal mining country, and rich in coal resources and has great potential. Its reserves account for about 90% of China's mineral resources. Coal industry is an important pillar industry in China. Coal gangue, which has not only occupied precious land but also destroyed ecological environment, is a by-product in the process of coal production. Its heat value is generally lower than 6.3 MJ · kg⁻¹[^1]. Its spontaneous combustion is also a primary environment problem in diggings. Toxic and harmful gases such as SO₂ and NOₓ are produced due to spontaneous combustion. Gangue is one of ten main industrial solid wastes of the world, but the second using source today. In coal production, coal gangue piles up in the form of gangue mountain. Every year, coal enterprises also need to invest a lot of money to solve such problems as the expropriation of coal gangue land, the pollution of gangue mountain and the natural disasters such as landslides and mudslides. How to solve the legacy of historical environment, coal gangue and to continue to produce reasonable and effective utilization of coal gangue, realize the resource recovery of solid waste, and to carry out the coal gangue high-end utilization way of experimental study, the increase of the coal industry and the support of circular economy, promote industrial structure adjustment and transformation of the mode of economic growth, improve the quality and efficiency of the development of coal industry, is the current main problems needed to resolve. China has also carried out a lot of work in the comprehensive utilization of coal gangue. Throughout this article analyzes the physical and chemical properties of coal gangue, summarizes the situation of comprehensive utilization of coal gangue in China, on the basis of summarizing the industrialized progress of our country in the aspect of comprehensive utilization of coal gangue, and the future development direction of comprehensive utilization of coal gangue in China was discussed.

Comprehensive Utilization of Coal Gangue

Chemical and Mineral Composition

Gangue is a collection of sedimentary rocks, and different sedimentary rocks are mainly composed of diagenetic minerals. Coal gangue is the rock that is caught in the coal seam and associated with coal and there are three main sources: the white gangue produced in the roadway excavation of the open-pit mining and coal mining, the common gangue selected in the coal mining process and the washing and cleaning gangue produced in the coal preparation process.[^2] The chemical composition of coal gangue produced in different areas is also different, mainly including SiO₂, Al₂O₃, Fe₂O₃, CaO, MgO, TiO₂ and K₂O. Among them, SiO₂ and Al₂O₃ are the main components of coal gangue, and
their total amount can reach 60% ~ 90%. In the course of coal gangue storage, spontaneous combustion will occur, in which volatile and carbonaceous combustion, its inorganic component content will increase. Coal gangue is widespread in the two kaolinite, quartz mineral crystal phase, there may be other mineral crystal phase include illite, chlorite, white mica, feldspar, pyrite and siderite, hematite, calcite, etc. In addition, coal gangue also contains a certain amount of amorphous material, mainly water, carbon, weathering and so on. [3] Pyrite and hematite are the main ore in coal gangue, and pyrite is also included in some newly produced gangue. Carbonate mineralcalcite is the main calcium bearing mineral in coal gangue.

**Comprehensive Utilization of Coal Gangue**

As a by-product of coal production, coal gangue mainly comes from mine gangue and washing gangue of coal washing plant. The production volume accounts for about 5% ~ 25% of coal production. Statistical analysis of the comprehensive utilization of coal gangue direction mainly concentrated in power generation, brick, filling subgrade filling ditch stretched out, very little use other ways, using the waste rock is given priority to with wash bottles, residual waste rock in the form of coal gangue piles. From the 1950s to the 1960s, China began to carry out comprehensive utilization of coal gangue, which is mainly used for power generation, brick making, reclamation, filling and road building. From 1990 to now, China's coal gangue treatment capacity has improved significantly, from 26 million tons in 1990 to 365 million tons in 2010, and the treatment capacity has increased 14 times. After 2010, the production has reached more than 600 million tons, and the processing capacity of comprehensive utilization of coal gangue in China cannot meet the increasing amount of coal gangue heap memory is becoming more and more big, reached 249 million tons in 2011. Moreover, as China's coal output continues to grow, the coal gangue production will continue to increase. It is estimated that 3.9 billion tons of raw coal will be produced in 2015, and 776 million tons of coal gangue will be produced. [4] Compared with the large amount of production, the comprehensive utilization of coal gangue is still insufficient.

**Main Problems in Utilization of Gangue**

With the increase of coal output, the amount of gangue has also increased. Although the comprehensive utilization of coal gangue in recent years has been realized through multiple ways, the comprehensive utilization rate of coal gangue is still very low. It causes a certain degree of ecological impact and environmental pollution. The accumulation of coal gangue is huge, and there are different degrees of spontaneous combustion in gangue mountain of high sulfur mining area. The coal gangue has become the industrial solid waste with the largest inventory and production and the largest occupation of the pile-up area. At the low end of the value chain, there is no effective way to utilize the high end. At present, the coal gangue in such aspects as power generation, brick has extensive application, but the added value is low, use is relatively small, mostly in the low-end value chain, the useful components of recycling waste rock and the preparation of high value-added products still less, and most are still in research and demonstration stage, far from mature form of technology. Lack of effective economic incentive and restraint policies and related supporting policies. The comprehensive utilization of coal gangue in the implementation of relevant policies has always been a great obstacle, involving a series of problems such as interests of different industries and supervision of related enterprises. For the recycling use of coal gangue, the enterprise of natural power is insufficient, in this situation, how to encourage and supervise the enterprise to carry out the comprehensive utilization of coal gangue, need to coordinate to solve a set of perfect system. There is a lack of talents in non-coal industry and the application of relevant industrial achievements is not smooth. Communication between coal industry and building material, chemical industry, combined with the bad, building materials, chemical industry, the results failed to effectively applied in coal industry and implementation of the lack of an effective mechanism of integration.
The Industrialization Progress of Coal Gangue in China

Building Materials

China first carried out the industrialization test of coal gangue brick making in Sichuan, Liaoning and other places. Sichuan Yongrong mining bureau is the first gangue brick factory in China to use coal gangue as raw material. Since then, Shandong, Liaoning and other places have also built gangue brick factories. But in this period, China's coal gangue brick production technology is simple, equipment performance is backward, product performance is poor, at a low level of development stage. Subsequently, the introduction of France, the United States, Italy, Germany, the main technology and equipment, on the overall performance of the coal gangue brick equipment have greatly ascend, gradually realized the mechanization of brick production line. And then, we introduced coal gangue hollow brick of hard plastic and half hard plastic extrusion equipment, by the end of the 1990 s, our country have been able to manufacture half-hard plastic extrusion and hard plastic extrusion equipment, formed with independent intellectual property rights of coal gangue brick technology, on the equipment level the coal gangue brick have greatly improved. Our country's coal gangue brick technology and equipment level, production scale, product variety and quality has reached the international level of the mid-1990s, the progress to promote the rapid development of the coal gangue brick industry in China. At present, the coal gangue system of conventional sintered brick, hollow brick has been a breakthrough in the production technology, such as its further development mainly relies on the innovation of production technology and advanced equipment, in addition, the development of multi-functional, many varieties of coal gangue brick gradually become the future development direction.

It is a very effective way to apply coal gangue to cement industry. It can not only utilize the heat value of gangue, save part of fuel, but also replace the clay used in cement production. In China, the application of coal gangue in the production of cement and cement mixture is also relatively early. However, the industrialization of coal gangue cement production was slow, until 2005, the cement production capacity of coal gangue and fly ash was only 29 million tons. It is difficult to break through the technical bottleneck of low admixture of gangue in cement. High quantity of coal gangue cement in development in our country has made a lot of effort, however, in actual production, the dosage of coal gangue is still very low, but in terms of coal gangue cement production is still stay at home and abroad on how to fully arouse the cement activity of coal gangue dosage to improve its application development phase.

Coal Gangue Power Generation

Coal gangue power plant mainly adopts the circulating fluidized bed boiler burning coal gangue (low calorific value of 1000 – 3000 kcal/kg) and low calorific value of coal power generation, power plant with bottles still is the main direction, washing and waste rock can make full use of waste rock in the waste heat, is one of the effective ways to a large number of consumption of coal gangue. The history of coal gangue power generation in China began in the 1970s, Sichuan and Jiangxi first carried out the industrial test of coal gangue power generation. In 2013, the supercritical 600,000 kw circulating fluidized bed power generation technology was successfully applied in Sichuan, which will be further applied to the construction of coal gangue power plant. Moreover, with the development of China's circulating fluidized bed power generation technology, the heat value of the fuel entering the furnace can be further reduced, and the coal gangue with lower heat value can be used for coal gangue power generation.

Ecological Disposal of Coal Gangue

It is an important way to make a lot of use of gangue to fill the ditches with coal gangue. Using gangue to fill in the trench to restore the land productivity, according to the local natural environment and social economy development situation, according to the economic and feasible, scientific and reasonable technology, the optimum comprehensive benefit and facilitate the operation of, in the
conditional place reclamation for dry land, where the insufficient conditions or temporary reclamation to forestland or grassland. Suitable for mountainous and hilly areas, it can reduce the adverse effects of surface storage and improve the local ecological environment. In view of the treatment of different types of gangue hills, different ecological restoration measures are adopted.

**Backfill of Coal Gangue**

The use of coal gangue for mine backfill, realizing green mining, reducing the amount of waste from the source, can consume a lot of coal gangue, more and more people's attention. It has been successfully tested in the tuulan mine of Xishan mining area. In coal mining, between two working face with coal pillar, with coal gangue filling roadway to replace this is along the empty left lane, by pillar along the empty left lane is one of the widely used way of roadway protection coal pillar, applied along the empty left lane, not only can greatly improve the recovery rate of coal resources, but also can ease the tight mining succeeded. However, due to the great differences in geological conditions, supporting materials sources and well size in different mining areas across the country, different types and technical levels of roadside support should be adopted according to local conditions.

**Other Industrialization Progress of Coal Gangue**

In addition to generating electricity, making building materials and being used for ecological disposal, we put forward the following high-end utilization directions of coal gangue according to its composition.

At present, in order to meet the fire protection requirements, the state has clearly prohibited the use of organic polyurethane insulation materials in building insulation materials, and promoted inorganic fire insulation materials. This is a good opportunity for the promotion and application of mineral fiber made from coal gangue and silicon aluminum fiber insulation material. Coal gangue ultrafine mineral fibre, as a new industry in domestic, energy saving, environmental protection, pure, good adaptability, low cost, high efficiency and wide market demand. Using gangue as raw material to produce silicon-alumina fiber, this foreign technology has been successfully studied and applied in China. Aluminum silicate fiber products can be used in petroleum, chemical, metallurgy, electric power, building materials, machinery, fiber textile and other industries such as refractory kiln, pipeline, boiler, storage tank, heat preservation, sound and heat resistance. Coal gangue in addition to power generation, building materials, high-end utilization, used for ecological treatment, is currently in the research, development of new technology is much, industrial raw materials can be produced, production zeolite molecular sieves, gangue ceramics grain.

Above all, coal gangue used to generate electricity, brick, fill out the ditch is stretched out the technology mature and widely used comprehensive utilization way, can consume a large amount of coal gangue, is using conventional methods, have a large number of promotion condition should be cenosphere, by using coal gangue mineral fiber, silicon aluminum fiber, nitrogen oxide refractory materials and other high-end products, its products with high added value and wide prospect of market, the potential is huge, the productive experiment should speed up the factory, this is the future development direction of comprehensive utilization of coal gangue.

**Conclusion**

Despite the industrialization of our country in comprehensive utilization of coal gangue has made significant progress, coal gangue comprehensive processing capacity has reached more than 400 million tons/year, but relative to the huge amount of coal gangue utilization way of existing is still difficult to meet the processing requirements of coal gangue, need to further strengthen the comprehensive utilization of coal gangue. High value-added utilization coal gangue is important supplement of the comprehensive utilization of coal gangue, and it will become the development direction of comprehensive utilization of coal gangue. Coal gangue in China has made the pace of industrialization of high value-added utilization.
References


